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Do groups fall prey to the winner's curse?

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DO GROUPS FALL PREY TO THE WINNER'S CURSE? *

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Abstract

In a company takeover experiment, groups placed better bids than individuals and substantially reduced the winner's curse. This improvement was mostly due to peer pressure over the minority opinion and to group learning. Learning took place from interacting and negotiating consensus with others, not simply from observing their bids. When there was disagreement within a group, what prevailed was not the best proposal but the one of the majority. Groups underperformed with respect to a "truth wins" benchmark although they outperformed individuals deciding in isolation. We draw general lessons about when to employ groups instead of individuals in intellectual tasks.

JEL Classifications : C91, C92, D03, D81

Keywords: winner's curse, takeover game, group decision making, communication, experiments

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1 Introduction

The winner's curse indicates a large overbidding in common-value auctions that likely leads to an expected loss for the auction winner. Experimental data has documented its persistence in controlled situations (Kagel and Levin, 2002) and field evidence has been accumulated for a variety of economic situations, from mineral right auctions (Capen et al., 1971), to baseball's free agency market (Belcherman and Camerer, 1998), to IPOs pricing (Levis, 1990) and to corporate takeovers (Roll, 1986). Investigations based on field data have been unable to pin down the origin of the winner's curse or to identify public policies or managerial procedures to lessen its impact. However, through laboratory experiments one can cleanly control the cost and information structure of the interaction in ways unavailable in the field.

Accordingly, we designed an experiment to understand if *groups* are able to overcome this robust behavioral bias better than *individuals* bidding in isolation. Two previous studies found that groups did not help to overcome the winner's curse in auctions with a common-value component (Cox and Hayne, 2006, Sutter et al., 2009). This paper takes a fresh look at the issue through the company takeover game introduced by Samuelson and Bazerman (1985). The essential features of the winner's curse exist in the company takeover game, which presents a much simpler environment than a multi-person auction and hence may provide cleaner evidence (Charness and Levin, 2009). Optimal bidding in auctions depends on involved calculations, belief about other's rationality, and on strategic uncertainty, which are absent in our company takeover game with a robot seller.[1] To the best of our knowledge, this is the first experiment investigating groups' behavior in a company takeover game.

[1] "the origin of this phenomenon [winner's curse] must stem from some form of bounded rationality, such as the decision maker's failure to recognize that a "future" event, per se, is informative and relevant for their current decisions, compounded by poor updating when this idea is even considered." Charness and Levin (2009).

In the company takeover game, a potential buyer makes a take-it-or-leave-it offer to a potential seller to acquire the target company. The seller can either accept or reject the offer. The seller will accept the offer if and only if it is higher than the company value to him. What makes the interaction non-trivial is that the seller has more accurate information than the buyer about the value of the company and is aware that the company will be worth 50% more under the management of the buyer. The seller knows the company value while the buyer knows the set of possible values, where each value may occur with equal probability.

In bidding, the buyer should consider the expected value of the company, when acquired. Importantly, companies that are worth more to the seller than the buyer's bid will never be transferred to the buyer. As a consequence, the expected value of the company acquired is *conditional* on the bid, because lowering the bid causes an adverse-selection in the values of the companies that will be acquired. In practice, many bids are around the *unconditional* expected value of the company, which yields lower expected profits and, in some settings, systematic losses. Several studies in management and economics have found a remarkably robust winner's curse in company takeover experiments (e.g., Charness and Levin, 2009, Bereby-Meyer and Grosskopf, 2008).

We adhered to the state-of-the-art of group experiments and compared treatments with individual versus group choices. The design allows both within and between subject comparisons in order to detect whether differences come from learning, aggregation of preferences, or both. Moreover, we recorded and coded messages exchanged by group members, following the methodology of content analysis (Krippendorf, 2004) and improving upon Cooper and Kagel (2005). The experiment presents several innovative features. First, before the discussion stage, each participant was required to post a bid proposal, a feature that saves discussion time and prevents shy members from being silenced. This piece of information allows us to perform an individual-level analysis of the group process for reaching a consensual choice. One can count the frequency of each aggregation rule in the groups and see if what emerged was the best proposal (truth-wins norm), the median proposal, the proposal of the majority, the worst proposal, a rotation scheme, or other rules. Second, we investigate what aspects of group decision-making affect performance, whether it is the simple exposure to diversity or group communication and negotiation. In a signal treatment, subjects could observe the bids of two other participants from the past sessions, without the option of discussing or the need of negotiating choices with them. In a group treatment, instead of individuals acting alone, groups of three members, who could chat and exchange bid proposals, submitted a joint bid. Third, in the group treatment, we granted veto power to each group member. If there was disagreement on the group choice after three attempts, everyone in the group earned zero. This generates strong incentives to communicate and to negotiate within a group. [2] Lastly, we also isolate the group effect on the task per se from the shift in risk attitude by measuring the extent of risky shift from individual to group decision making. We report that groups substantially reduced the winner's curse and generally placed better bids than individuals deciding in isolation. Groups underperformed with respect to a "truth wins" benchmark (Lorge and Solomon, 1955), although they outperformed individuals. This result was attributed to both the effect of group learning *and* the aggregation rule within the group. When there was disagreement within a group, what

[2] Existing studies of group decision making greatly differ on this point, which crucial affects the incentives for communicating with others and for convincing them of one's opinion (Zhang and Casari, 2009). Cooper and Kagel (2005) randomly select one member's proposal as the group choice. Blinder and Morgan (2005) and Gillet et al. (2009) either implement a majority rule or give members no time limit to reach a unanimous decision. Kocher and Sutter (2007) is the most closely related paper with a veto power feature. In a gift-exchange game, Kocher and Sutter allowed groups of three up to 10 rounds to reach agreement. If there was no agreement in the 10^{th} round, each group member received only a show-up fee of $20. Only one group failed to reach an agreement. They didn't analyze the effect of such veto power though. Kagel et al. (2010) studied the veto power in a committee where only one of the three committee members is a veto player.

prevailed was not the best but the opinion of the majority. This result is not an unconditional endorsement of the superiority of groups over individuals, but leads to punctual implications about when to employ groups and when to employ individuals in decision making.

The remainder of the paper is organized as follows. Section 2 reviews literature on the winner's curse and group decision-making. Section 3 describes theoretical predictions, experimental design and procedures for the present study, and section 4 reports the main results of our study. Section 5 examines alternative explanations for the superiority of groups over individuals, while section 6 analyzes the content of group communication during the company takeover task. Section 7 concludes with practical implications of the study findings.

2 Literature Review

The present study draws from both the literature on the winner's curse and group decision-making in order to support our proposition that individuals working in a group are less likely to fall victim to the winner's curse than individuals working alone. We will review both literatures relevant to this proposition, starting with the winner's curse. The main experimental finding of the common value auction literature is that the winner's curse is a robust phenomenon in many auction formats (Kagel and Levin, 2002). The literature further argues that such persistent losses (or below-normal profits) are not part of any equilibrium behavior with fully rational bidders and that the winner's curse would eventually correct itself given sufficient time and the right kind of information feedback. In practice, though, most of the adjustment toward the rational strategy happens through *market* learning as the less skilled firms and bidders go bankrupt and exit the market (Casari et al., 2007, Kagel and Levin, 1986). The brutal force of market selection intervenes because *individual* learning is much slower than market forces. One way around this intervention could be to study group decision makers in the absence of market selection. This paper examines the conditions under which groups will eventually learn to avoid the winner's curse in the setting of a company takeover. We review eight experimental studies that have utilized the company takeover game in the economics and management literature.[3] In all of these studies, decision makers were individuals. In none of them, does the winner’s curse disappear with a reasonable amount of experience and feedback. Indeed, individuals in these studies failed to avoid the winner's curse even when they were paid for good performance, when their intellectual reputations were at stake, when they were given hints, and when unusually analytical participants were used.

In the experiment, we followed the state-of-the art design features for company takeover studies. First, some studies place the equilibrium bid at the corner of the choice space, either at 0% or 100%, or in the middle at 50%.. We changed this to avoid classifying noisy players as mostly out of equilibrium or mostly at equilibrium (Holt and Sherman, 1994, Selton et al., 2005). Second, most of the studies on the company takeover game found a very high share of sub-optimal bids, suggesting that the task is well beyond the ability of participants to solve it. Following Charness and Levin (2009), in our experiment the task was simplified by adopting a discrete and small set of company values for the seller. Third, existing studies have varied in repeating the task from 1 to 100 but generally have found that a very slow improvement in performance with repetition. We had participants repeat the task 26 times, which still allowed us to detect learning. Fourth, all studies used robot sellers, so do we, with the exception of Carroll et al. (1990, treatments 5 and 6 only).

The group decision-making literature provides some insights into group performance

[3] Ball, Bazerman, Carroll (1991), Charness and Levin (2009), Holt and Sherman (1994), Selton, Abbink, and Cox (2005), Bereby-Meyer and Grosskopf (2008), Grosskopf, Bereby-Meyer, Bazerman (2007), Carroll, Delquie, Halpern, Bazerman (1990), Tor and Bazerman (2003).

relative to individuals on a task such as the company takeover game. The psychological literature on group versus individual decision-making distinguishes between judgmental and intellective tasks. A judgemental task involves problems where there is no obvious “correct” action and individuals may legitimately differ on their choices because of their values or preferences. An example of this task is choice under risk (Stoner, 1961), ultimatum games (Bornstein and Yaniv, 1998) and the dictator game (Cason and Mui, 1997). In a review of individuals’ and groups’ resistance to judgmental biases, Kerr and his colleagues found that groups may actually amplify rather than suppress judgmental biases regarding errors in how information is used, errors caused by overlooking useful information, and errors caused by a reliance on mental rules of thumb that oversimplify the decision (Kerr et al., 1996). In contrast, an intellective task has a demonstrably “correct” solution. While this solution may be difficult to discover, it is self-explanatory once discovered and can easily be demonstrated to others (Cooper and Kagel, 2005). We argue that the company takeover game is closer to an intellective task because once a subject understands what the optimal bid is; it is straight forward to explain it to others. In comparing individual and group performance, Lorge and Solomon (1955) proposed to replace absolute performance of the group with the “truth wins” benchmark (i.e., the group should be able to achieve a correct answer if at least one member would have chosen it in isolation). Thus, if a fraction p of individuals working alone reaches the correct solution, the probability that in a randomly selected group of n persons at least one knows it is $1 - (1\text{-}p)^{n}$. The truth wins benchmark sets a higher standard for the group superiority than absolute performance. While the management literature on intellective tasks suggests that the absolute performance of groups is superior to the performance of individuals (Laughlin et al., 2003), research on group performance in the psychology literature documents that freely interacting groups very rarely exceed and usually fall below the truth wins standard (Davis, 1992).

Results from experimental economics on group performance in intellective tasks are more mixed. In a beauty-contest game, Kocher and Sutter (2005) found that groups of three subjects did not do more iteration of reasoning than individuals, but learned faster than individuals via face to face communication. In a common value auction, Cox and Hayne (2006) documented that groups of five subjects who could talk face to face fell prey to the winner's curse to a similar extent than individuals or more, depending on the treatment. More precisely, groups underperformed individuals when group members had to exchange more information. In an ascending sealed-bid English auction with both private and common value components, Sutter et al. (2009) reported that groups of three who submited a joint bid after face to face communication were *more* likely to fall prey to the winner's curse. Apparently, groups competing with other groups in auctions are more "aggressive" than individuals competing with other individuals. Our experiment eliminates the interaction between bidders by using a robot seller who accepts the buyer's bid as long as it is equal or higher than the company value. Moreover, with a company takeover game it is easier for bidders to explain to others the rationale for the optimal bid than in the common value auction, because there is no need to consider the bids of other potential buyers.[4] In signalling games, Cooper and Kagel (2005, 2009) reported that teams of two play more strategically than individuals after exchanging messages in online chatrooms and a change in the meaningful context of the game stalled individual learning process but had no effect on the strategic play of teams. Cooper and Kagel (2005, 2009) conclude that teams of two outperformed the truth win benchmark using a simulation of team play based on randomly drawing two individuals from the individual treatment. Instead of

[4] A typical quote on reasoning of the optimal bid in the company takeover game is: "let's not go with 90 because the only way we can make money is if its [the company value] 90. [the company value] might as well go with 60, it came out less times, and if 38 comes out we don't lose as much and 60 makes the most economic sense."

relying on simulated data, our within-subject design allows us to count the instances in which the optimal proposal from the individual member prevailed to a final group choice. Also, we examined team play in groups of three rather than two, which permits interesting majority or minority behaviour.

3 Predictions, Experimental Design and Procedures

The experiment is framed as a company takeover game where there is a buyer and a seller who move sequentially (Samuelson, 1984, Samuelson and Bazerman, 1985). The buyer makes a take-it-or-leave-it offer $b \in \{0, 1, 2, \ldots, 360\}$ to a seller whose company's value is s. The seller either rejects or accepts the bid. The payoffs for the seller are s if she rejects and b if she accepts. The payoffs for the buyer are 0 if the seller rejects and $(1.5s - b)$ if she accepts. The company can have five possible values, $s \in \{38, 60, 90, 130, 240\}$. When making a decision, the seller has private information about s, while the buyer knows that each realization of s has equal probability.

Hence, the task is a bilateral bargaining problem with asymmetric information and valuations. The informational disadvantage of the buyer is offset by an assumption that the buyer's value is 1.5 times the seller value, s. A rational buyer has the following objective function (1), where $\mathrm{I}_{\{b \geq x\}}$ equals 1 when the bid $b \geq x$ and 0 otherwise:

(1) Rational objective:

$$\Pr(b \geq s)\left[1.5 \cdot \left(\frac{38 \cdot \mathrm{I}_{\{b\geq 38\}} + 60 \cdot \mathrm{I}_{\{b\geq 60\}} + 90 \cdot \mathrm{I}_{\{b\geq 90\}} + 130 \cdot \mathrm{I}_{\{b\geq 130\}} + 240 \cdot \mathrm{I}_{\{b\geq 240\}}}{\mathrm{I}_{\{b\geq 38\}} + \mathrm{I}_{\{b\geq 60\}} + \mathrm{I}_{\{b\geq 90\}} + \mathrm{I}_{\{b\geq 130\}} + \mathrm{I}_{\{b\geq 240\}}}\right) - b\right]$$

(2) Naïve objective:

$$\Pr(b \geq s)\left[1.5 \cdot \left(\frac{38+60+90+130+240}{5}\right) - b\right]$$

A bid of 60 is the risk-neutral Nash equilibrium (RNNE) strategy for the buyer and yields an expected profit of 5.4. Table 1 shows buyer's profits for the RNNE strategy and other bidding strategies. Instead, an incorrect reasoning may lead some participants to bid 90 and earn an expected profit of 2.4, which is sub-optimal. We computed this prediction following the Holt and Sherman (1994) model of naïve bidding (2) in order to select a design for the experiment with a rational bid lower than the naïve bid. A naïve bidder does not condition the value of the company on the level of the accepted bid, rather, assumes that the value is always the expected value of *s*, which is 111.6. As illustrated by the objective (2), a naïve bidder erroneously thinks a bid of 90 would yield an expected profit of 0.6·(1.5·111.6 – 90)=46.44. Instead, when placing a bid of 90, the company is sold only for values *s* 38, 60, 90 but not for 130 and 240. As illustrated by (1), the expected value conditional on being accepted is not 111.6, but (38+60+90)/3 = 62.66. Thus, the expected profit is 2.4 (Table 1). When the buyer does not take into account that acceptance is itself an informative event, the buyer may overbid and even incur an expected loss.

The possible company values for the present study were chosen to satisfy some requirements. First, to make the task easier to tackle, it has only a discrete number of company values; two pilot experiments suggested that with three values the task was too easy for our subject pool and with one hundred values it was too difficult. Second, in order to ensure that the participants were engaged in the task, it was necessary to have an RNNE bid with a substantial probability of acquiring the company. In our design, this probability was set to 40%. Third, to ensure that the naïve bid was higher than the rational bid; after fixing the lower four company values one needs to add a very high maximum company value; we decided that the maximum bid would be 240, in order to put a large enough profit distance between the RNNE and naïve bid according to expression (2).[5] Third, we avoided placing the RNNE and the naïve bids at the extremes values (i.e., 38 or 240). Sellers were simulated by a computer accepting only when the bid *b* was greater than or equal to *s*. This simplified game allows us to isolate the origins of the winner's curse from possible explanations such as complicated strategic interactions between sellers and buyers and misunderstanding of the game.

We manipulated the decision making process in a company takeover task using three treatments: Individual decision making (*Individual*), individual decision making when observing the bids of two other people (*Signal*), and group decision making (*Group*). Each session included four parts (1) individual risk attitude elicitation using a multiple price list design for one period; (2) group risk attitude elicitation using a multiple price list design for one period; (3) individual company takeover game for six periods; (4) company takeover game with procedures differing by treatment for twenty periods.[6] Our main interests are with parts 3 and 4; however, parts 1 and 2 provided a benchmark to evaluate results. We will now describe each part in detail.

There were a total of 15 participants in each session. In part 1, we measured participants' risk attitude with fifteen binary choices between lotteries. Although, no studies we reviewed in section 2 (footnote 3) did it, the elicitation of risk attitudes may help in the interpretation of choices in the company takeover game. The overall incentive structure was similar to that in Holt and Laury (2002). Participants chose between a "safe" Option A and a "risky" Option B. The payoff of Option A was deterministic (50 tokens) and the payoffs for Option B were either 150 or 0. On the first decision, the probability of the high payoff (150) for Option B was zero. In

[5] According to objective (2), with a fifth company value of at least 183, a 60 and 90 bids yield equal "profits"; with a 240 value, the "profit" distance is 7.5%.
[6] We adopted the same group composition in part 2 group risk attitude elicitation and in part 4 group company takeover game.

subsequent choices, the probability of the high payoff increased by 1/20 each line, {0, 1/20, …, 14/20}. A risk neutral person would choose A in lotteries one through seven and then switch to B in lottery eight. Risk seeking agents may switch to option B earlier than lottery 7 and risk averse agents may switch later than lottery 7. Any rational agent should choose option A over option B in the first lottery (50 vs. 0 francs always) and later on eventually switch to B. Multiple switches would be a signal of confusion. We gave a payout for only one of the fifteen decisions, chosen randomly at the end of the session. Random choices were all implemented through drawings from a bingo cage.

In part 2, participants were randomly divided into groups of three and faced the same task as part 1. Hence, there were five groups in each session. In this group version, for each of the fifteen lottery choices, there was a proposal phase, a chat phase, and a group choice phase. In the proposal phase, all group members simultaneously made an individual proposal about each of the fifteen lottery choices, followed by immediate feedback regarding disagreements. At this point, participants could switch to a chat window and had two minutes to send free-format messages to others in their group. We asked participants to follow two basic rules: to be civil to one another and not use profanities, and not to identify themselves in any manner. Messages were recorded. In the chat window, participants received an id number 1-3 in the order they sent messages in that specific period. After about two minutes, everyone had to submit a choice for the group decision. A group choice had to be unanimous (i.e., for the specific decision line, choices of all three group members must be identical). If there was unanimity on all fifteen choices, then part 2 was over. Otherwise, the line(s) with disagreement was (were) highlighted again, and all three group members were invited to submit a new proposal. If there was still disagreement, there was another final round of proposals. At this point, part 2 was over even if disagreement remained.

Participants were paid for only one of the fifteen decisions, which was chosen randomly at the end of the session. Random choices were all implemented through drawings from a bingo cage. If the group was still in disagreement by the end of part 2, then the group earned zero for part 2.

In part 3, all participants faced six periods of the company takeover game as potential buyers. Participants started part 3 with a 200 token endowment. There was a practice period with forced input. Every period the computer drew 15 company values in each session, one for each participant. To favor learning, each participant observed the company value that was drawn both when the company was acquired and when it was not, and were required to write it along with their bid and period profit on a record sheet. Participants were paid for all six periods based on their performance. Note that when cumulative earnings were low, there was a problem of limited liability, which we will discuss in the Result section. The instruction explained:

"What if my earnings are negative? They will be compensated with your other gains. More precisely, if you have a loss in a single period, it will decrease your cumulative earnings. If your cumulative earnings in this part are negative, they will decrease your earnings in other parts of the experiment. However, if at the end of the session your earnings are negative, you will receive $5."

Part 4 comprised twenty periods of the same company takeover game they faced as individuals in Part 3. At the beginning of Part 4, each participant received an endowment of 300 tokens. Rules for Part 4 differed from treatment to treatment as described below.

For the *Group treatment*, in part 4, participants faced the company takeover game in groups of three members. Groups were the same as in part 2 and every period they had a proposal phase, a chat phase, and a bidding phase. In each period, participants initially shared their proposals with others, in particular: (1) a bid proposal (an integer between 0 and 360) (2) a confidence level in the bid (low, medium, high), and (3) a brief text with reasons for the choice of that bid (optional). This information was placed on a public board for all three group members to see. At that point, participants could switch to a chat window for up to two minutes after which they submitted a bid for the group decision without further possibility to chat. If the individual bids of all three group members were identical (unanimity), then it became the group bid and part 4 was over. Otherwise, all three group members were invited to submit new bids. If there was still disagreement, there was another final round of bidding. Disagreement implied that no bid was submitted. Every period the computer drew five company values for each session, one for each group.

For the *Individual treatment*, in part 4, the task was identical to part 3 except for minor procedural changes. When submitting a bid, participants had to submit (1) their confidence level in the bid (low, medium, high) and (2) a brief text with reasons for the choice of that bid (optional). In the Individual treatment, only the experimenter could observe this information. Every period the computer drew five company values for each session, one for each group of three persons that was formed in part 2.

For the *Signal treatment*, part 4 was identical to the Individual treatment except for one element. Participants chose individually their bid level and *were informed about the bids of two other people*. More precisely, we used the data from the individual treatment sessions (part 4) and displayed, period by period, the bids independently placed by two people. To make the decisional process more comparable across treatments, we employed the same random draws realized in the individual treatment sessions.[7] When submitting a bid, participants were required

[7] More precisely, consider a group of three members formed in part 2. In the signal treatment each group member received the same random draw. For "signal" member 1 we displayed the bids of "individual" members 2 and 3. For "signal" member 2 we displayed the bids of "individual" members 1 and 3. For "signal" member 3 we displayed the bids of "individual" members 1 and 2. Session dates were 27 Sep 07, 23 Oct 07 (Individual), 28 Oct 07(a), 28 Oct

to submit (1) their confidence level in the bid (low, medium, high) and had the option to submit (2) a brief text with reasons for the choice of that bid (optional).

For all parts of the design, we distributed written instructions, which were read aloud. The experiment was performed with a z-tree application (Fishbacher, 2007). No person participated in more than one experimental session. We guaranteed a minimum payment of $5 for everyone showing up on time, left the experiment, or participated but earned overall less by the end of the session. We converted each experimental token to actual dollars at the rate of $0.03. A session lasted on average about 2 hours and average earnings per person were about $20. We conducted eight experimental sessions with 15 participants for a total of 120 people; 60 people were in the Group treatment and 30 each in the Individual and Signal treatments. Participants were recruited from the undergraduate campus population of (omissis) University.

4 Main Results

Result 1*: In the individual treatment of the company takeover game, there was no significant learning over time in the following measures of performance: (1) the fraction of optimal bids, (2) the fraction of winner's curse bids, and (3) the fraction of dispersed bids.*

We first report the bidding of participants in isolation in the company take over game (Table 2, part 3 in all treatments, col. a, c, f). Note that when aggregated across all sessions, 28.1% of bids were optimal and 23.1% were winner's curse bids.

Table 3 (col. a and col. b) puts forward various probit regressions to explain when an individual bid was optimal or when it was a winner's curse bid in part 3, across all treatments, for periods one through six. Regressors included past company values, risk attitude, levels of

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07(b) (Signal), 25 Sep 07, 2 Oct 07, 4 Oct 07, 11 Oct 07 (Group). For the signal session 28 Oct 07 (a) we used the random draws of individual session Sep 27 and for signal session Oct 28b we used the random draws of individual session 23 Oct 07.

confidence indicated on the proposed bid, measures of skill, demographic characteristics, a trend dummy (1/period), and session dummies.[8] The results show that science and engineering major placed optimal bids significantly more often than Economics & Business and other majors (Table 3, col. a). The results also show that ability captured by SAT/ACT scores mattered in handling the company takeover game. Bottom quartile of the SAT/ACT takers was likely to place less optimal bids and more winner's curse bids. No gender effect was observed.

Now let us focus on the individual treatment. Overall, a minority of bids were at the optimal value of 60. There were 35.6% optimal bids in part 3 (Table 2, col. a) and 37.5% optimal bids in part 4 (Table 2, col. b). This difference was not significant according to a Wilcoxon signed-rank test.[9]

As sub-optimal bids were the majority of bids placed, we present two other measures of performance. Winner's curse bids are those that yield an expected loss, which are in the intervals (57, 60), (73.5, 90), or (94, 360). A subject is better off to bid 0, rather than placing a winner's curse bid. In part 3, about 20.0% of the bids were winner's curse bids and 18.3% in part 4. This difference was not significant according to a Wilcoxon signed-rank test (N=30, p=0.50). Moreover, any bid in between 0 and 360 is weakly dominated by 38, 60, 90, 130, or 240. Even if unable to identify the optimal bid, participants should recognize that bids different from the ones above are dominated. We call these bids "dispersed," but exclude from the definition 39, 61, 91,

[8] In terms of risk attitude, risk seeking participants are coded as one when they switched from option A to B at question seven or earlier, while participants who switched at question 13 or later are coded with risk averse dummy equals one. Hence, risk averse dummy identifies participants with a very high degree of risk aversion, rather than every risk-averse participant. One dummy regressor coded whether the subject had high confidence in the bid placed. Participants were asked to indicate the confidence level only in part 4 of all treatments. Skill proxies were the SAT/ACT scores obtained from the university Registrar's Office. SAT/ACT scores were collected for 92.5% of the participants (missingdata=0), who are coded using the US nationwide distribution of the SAT-takers (College Board of Education, 2006). The threshold for low ability was set at the lower quartile. The cutoff values were the average between male and female national tables. Other demographic variables we included were gender, economics and business major and science and engineering major.

[9] N=30, p=0.316 when considering all periods of Part 4; N=30, p=0.316 when restricting to the last 6 period of Part 4.

131, and 241 in case participants did not understand the tie-breaking rule. No dispersed bids should be placed in equilibrium. The fraction of dispersed bids declined from 9.4% in part 3 to 4.8% in part 4. This difference was not significant according to a Wilcoxon signed-rank test (N=30, p=0.66).

Table 3 (col. c and col. d) presents probit regressions to explain when an individual's bid was optimal or when it was a winner's curse bid from the individual treatment of periods 7-27, part 4. In comparison to columns a and b for part 3, columns c and d include one new dummy regressor, which was whether the subject had high confidence in the bid placed (highconfidence=1). Participants were asked to indicate the confidence level only in part 4 of all treatments. This dummy shows no significant effect. Contrary to part 3 result, Economics & Business major catch up in periods 7-27 (part 4). Men were more likely to place a winner's curse bid. This result is at odds with findings by Casari et al. (2007) in a common value auction setting where they found that women performed worse than men. The significant effects of SAT/ACT scores also disappear.

Result 2*: In the group treatment of the company takeover game, there was significant learning in the following measures of performance: (1) the fraction of optimal bids, (2) the fraction of winner's curse bids, and (3) the fraction of dispersed bids.*

Table 2 (group treatment) and Figures 1, 2, and 3 provide support for result 2. The fraction of optimal bids in part 3 was 30.6% and increased to 50.5% in part 4. This difference was significant according to a Wilcoxon signed-rank test (N=60, p=0.0004). The fraction of winner's curse bids in part 3 was 18.3% and declined to 9.75% in part 4. This difference was significant according to a Wilcoxon signed-rank test (N=60, p=0.032). The fraction of dispersed bids was 11.1% in part 3 and it basically disappeared in part 4 (0.2%). Also, this difference was significant according to a Wilcoxon signed-rank test (N=60, p=0.002). Result 2 holds also when we account for limited liability issues. One can see that for low cash balances (below 23.25 tokens) it is optimal for a subject to bid 240 instead of 60.[10] At some point, five participants had low cash balances and bidding 240 was optimal. These occurrences involve only 1.2% of all bids. Removing these observations did not change Result 2, because the issue affected part 4 relatively more than part 3, and the group treatment relatively more often than the individual treatment (Table 2). To avoid confounding effects, we dropped these observations from all regression analysis.

For the group treatment, part 4, we studied in more detail the process of making proposals in the group. Table 3 (col. e and f) puts forward various probit regressions to explain when an individual proposal was optimal or winner's cursed in part 4 for the group treatment. First, the significant negative relationship between risk averse and likelihood to fall prey to winner's curse conforms our conjecture that more risk averse participants would choose to bid 38, while risk seeker may bid 90. Yet, we will discuss later that aggregated group risk preference cannot account for group improvement over individual bids, as groups are closer to risk neutral rather than risk averse decision makers. Second, participants who had high confidence in their proposals were less likely to make winner's curse bids. Third, there is a significant improvement of the fraction of optimal proposals over time (negative coefficient on trend dummy 1/period), which is in contrast with the absence of improvement observed in the individual treatment. Fourth, there was no significant effect of major, skill, and gender.

[10] Bidding 240 yields a 120 profit with probability 0.2 and a loss y with probability 0.8.The variable y is the minimum between the actuall loss (i.e. 240 minus the value of the company) and the cash balance. If the cash balance is below y the loss is inconsequential. When y<23.25 the expected profit from a 240 bid are higher than 5.4 i.e. the expected profits from a 60 bid. Two caveats are in order. First, we guarantee $5 minimum earnings, which translates into 166.6 tokens, hence the relevant threshold for cash balances is 189.9. Second, the reference cash balance includes the expected earnings from part 1 and 2 lotteries, the part 3 and 4 endowments and the cumulative profits from the company takeover game up to that period.

Result 3*: The group treatment outperformed the individual treatment in the fraction of winners' curse bids and the fraction of dispersed bids.*

Table 2 provides support for Result 3. We conducted a series of Mann-Whitney tests on cross-treatment comparisons for part 4. The group treatment exhibited less winners' curse bids (n=30, m=60, p=0.058) and less dispersed bids (n=30, m=60, p= 0.007) than the individual treatment.[11] There is no reason to believe that this better performance comes from more high skilled participants participating in the group treatment than in the individual treatment sessions. In fact, in part 3 the group treatment had no significantly different levels of optimal bids, dispersed bids and winner's curse bids (n=30, m=60, p= 0.928 for optimal bids, p= 0.118 for dispersed bids, and p= 0.080 for winner's curse bid). Also, in part 4, there were more optimal bids in the group treatment than in the individual treatment, but the difference was not significant (n=30, m=60, p= 0.168).

5 Explanations of the Main Results

Why do groups outperform individuals? In order to answer this question, we look at three possible aspects regarding how groups decided on their bids: aggregation of risk attitude in group decisions, observational learning, and the aggregation of individual proposed bids within the group.

Can patterns of risk attitude explain the winner's curse phenomenon? Not in this experiment. Risk attitudes explained neither the point predictions of the individual treatment nor the comparison across individual treatment and group treatment. While for the buyer, the Risk Neutral Nash Equilibrium (RNNE) bidding strategy is to bid 60, participants which were risk

[11] An observation is the fraction of bids in the relevant category for each subject in all part 4 periods. We get similar results if we treat a group of 3 as an observation instead of 3 observations. The group treatment has also significantly more optimal bids (n=30, m=60, p= 0.006) than the signal treatment.

averse may choose to bid 38 and risk seeking may bid 90. Bidding 130 or 240 yields negative expected payoff, and hence should never be chosen. The differences in individual risk attitude we observed from part 1 cannot explain the winner's curse phenomenon. Less than six percent of the participants showed risk seeking behaviour in part 1, and hence 94% of bids should be either 38 or 60. Instead, in the individual treatment, they were 47.5% (Table 2, col. b).

The shift in risk attitude cannot explain the better performance of groups than individuals. A potential explanation for group improvement is a prudent shift in risk attitude when individuals decide in a group instead of in isolation. As reported below in Result 4, this does not seem to be the case. Hence, we can rule out risk attitude as an explanation for the observed individual-group differences in bidding.

Result 4*: The shift in risk attitude generated by group decision-making cannot explain the better performance of groups over individuals in the company takeover game. In lottery choices, groups are closer to a risk neutral decision maker compared to individuals.*

Figure 4 illustrates the lottery choices in part 2 of 120 participants divided into 40 groups. Each group made 15 choices for a total of 1800 individual decisions. In 73.5% of the group decisions, everyone was in agreement. We focus exclusively on those decisions where there was disagreement. Disagreement is defined by comparing individual choices (part 1) and group choices (part 2). There were 465 group decisions with disagreement as illustrated by the line in Figure 4. What rule governed conflict resolution within a group in disagreement? Most of the time, the median member determined the group decision (76.8% of cases), while in other cases, there was a risky shift (16.8%), and in other cases there was a prudent shift (6.5%). The data on choices over lotteries suggest that the median member choice is the most widespread aggregation rule. However, there is a nontrivial amount of group decisions that are more risky than the decisions taken by the median member. [12]

In our sample pool, the fraction of risk seeking groups was 2.6%, which was lower than the fraction of risk seeking individuals, 5.7% (prudent shift). A two-sample Kolmogorov-Smirnov test did not show a significant difference though (p=0.875). Moreover, this explanation for the improved group performance is weak because it is counterbalanced by a massive opposite shift—risky shifts (Figure 4). Overall, we found that group choices were closer to the behavior of a risk neutral agent than individual choices.

Result 5: *When individuals can observe the bids placed by two other participants in the company takeover game (i.e., the signalling treatment), there was no significant improvement in performance in comparison with the individual treatment.*

Table 2 and Figures 1, 2, and 3 provide support for Result 5. In Table 2, part 4 of the signal treatment, there were 29.7% of optimal bids, 18.3% of winner's curse bids, and 4.7% of dispersed bids (Table 2). According to a series of Mann-Whitney tests, they were not significantly different from the individual treatment (n=30, m=30, p=0.258 for optimal bids, p=0.670 for winner's curse bids and p=0.405 for dispersed bids). However, in the group treatment, participants achieved a significantly higher frequency of optimal bids (n=60, m=30, p=0.006) than in the signal treatment. [13] In fact, in part 3 of the signal treatment there are significantly less optimal bids than in the corresponding part of both the individual and group treatments (n=30, m=30, p=0.011 for comparison between signal and individual treatments; n=60, m=30, p=0.004 for comparison between signal and group treatments).

[12] Baker et al., (2008) show that groups choose significantly more low-risk lotteries than the mean choice of the individual group members in a within-participants design (Individual-Group-Individual). Yet, in a between-subject design (participants play as an individual or group, not both) they find no significant difference, but the groups tend to make decisions that are more consistent with risk neutral preferences in the lowest and highest risk lotteries. We also find that groups are more close to risk neutral choices than individuals in our design.
[13] Mann Whitney tests on the SAT/ ACT across treatments indicate no significant difference across treatments. Thus the superiority is not due to less capable subjects showing up in the signal treatment.

As for the other treatments, Table 3 presents probit regressions on who placed optimal or winner's curse bids (col. g and h). Regressors for the signal treatment control for the type of bids subjects observed. More specifically, whether at least one of the observed bids, or both, were optimal; whether at least one of the observed bids, or both, yielded an expected loss. According to the regression results, participants did not strongly react to the observed bids and when they did react, it was sometimes in an unexpected direction. The regression shows an improvement in optimal bids over time.[14] Yet, according to a series of Wilcoxon signed-rank tests comparing the fractions of optimal bids and winner's curse bids between part 3 and part 4, the learning in part 4 is neither enough to increase the fraction of optimal bids nor to reduce the fraction of winner's curse bid (N=30, p=0.064; N=30, p=0.094). There was no significant difference in terms of dispersed bids (N=30, p=0.366).

We argue that the reason for the superiority of groups over individuals lies in the way individual opinions were aggregated into a group choice, as explained below.

Result 6*: When there was disagreement among group members on what bid to place in taking over the company, the median proposal prevailed in 75% of the cases. The final group bids were better than the median proposal in 7% of the cases and worse than the median proposal in 17% of the cases. Groups underperformed with respect to a "truth wins" benchmark.*

A key feature of the group treatment in part 4 is to ask for individual bid proposals before the group discussion; hence there is a complete record of ex-ante agreement or disagreement among group members. At the proposal stage, group members unanimously agreed 46.2% of the time. In all other instances, there was disagreement (i.e., at least one member placed a proposal

[14] The estimated coefficients for High confidence proposal, bottom quartile SAT/ACT scores, Science and Engineering have sometimes a different sign than in the other treatments.

different from the group bid). Hence, there was lively disagreement within groups; especially in the initial periods. At the group bid stage, all groups eventually reached a unanimous group decision.

We focus on the subsample where there was disagreement on individual proposals in order to understand how the group dynamic aggregated diverging opinions. Table 5, specifications (a) report the results from probit regressions on the disagreement subsample. The dependent variable was 1 when an individual proposal became a group choice, 0 otherwise. After controlling for risk attitude, confidence level, major, gender and skills, we also included a dummy for participants with low cash balance, a dummy for a median proposal that was also a majority proposal, a dummy for a median proposal that was not a majority proposal, and a dummy for the best proposal in a group which yielded the highest expected payoff. Period dummies were also included but not reported in the table.

In the first regression, we pooled data from periods 1 to 6 where participants learned how to play the game in a faster rate than the latter periods. The second regression is based on data from periods 7-20. The comparison between the regressions using the first 6 and the last 14 periods allowed us to examine the change in the determinants of group outcome across time. The main result from specifications (a) is that the median proposal was the strongest determinant of group choice, especially when it was a majority proposal. . Such strong impact remains over time. *The best proposal had no significant effect on group choices initially and was less likely to prevail as group choices later on,* which suggests that the "truth wins" norm does not apply to this experiment. In the early periods, more risk seeking participants, who had bottom 25% SAT/ACT scores, were less likely to convert their proposals to group choices. These significant effects disappeared after period 6 though. High confidence, major and gender did not seem to be important factors.In intellective tasks, such as the company takeover game, one smart subject who knows the optimal bidding strategy can explain it in the chat to the other two group members and hence prove to them the superiority of his or her proposal.[15] In a well-working group, this may well happen but it did not in the experiment. Consider the following back-of-the-envelope calculation. About 30.6% of part 3 bids were optimal. Absent any learning, the chances that at least one group member proposed the optimal strategy were 66.4%. Actual optimal bids in group decisions of part 4 were 50.5%, which is considerably less than a “truth wins” norm (Table 2).

By design, every participant had veto power in group decisions. Recall each group had three rounds to reach a unanimous bid after the individual proposals were revealed and text messages were exchanged among them. If there was disagreement on the final bid, the group lost the opportunity to place a bid for the period and everyone in the group earned zero. The veto power could have been usefully employed by a subject every time others in the group wanted to place a winner’s curse bid. For risk neutral and risk averse participants, a sure gain of zero is preferred to an expected loss. Did participants employ such veto power? Not much. First, there was no case where groups did not reach a final bid by the third trial. Second, the aggregation of winner’s curse proposals did not differ from the aggregation of proposals in general (Table 4). When the proposal of one member was winner’s curse bid and the other two were not, it prevailed in 25.0% of the cases. When the proposals of two members were winner’s curse bids and the other was not, it prevailed in 77.8% of the cases. These percentages are aligned with those stated in Result 6. In the hypothetical case that a subject with a non-winner’s curse proposal always vetoed group decisions for a winner’s curse bid, in the group treatment in part 4,

[15] At the beginning of each period, subjects must make a proposal in the pre-discussion stage which worked as an open brick for their discussion and also saved their chat time which was up to 2 minutes. There were 15 periods involved. Thus the smart subject had 30 minutes in total to explain the strategy to other two group members.

only 1.5% of bids would have been winner's curse (and not 9.75%). In other words, a rational use of veto power could have substantially reduced the fraction of winner's curse bids. Participants simply did not employ it as much as they could. Our conjecture is that this is due to pressure to conform in group decision making.

One aspect that needs clarification is how group decisions strictly based on the median bid proposal could improve performance in the company takeover game. We ran simulations by taking the median bid among three randomly drawn individual bids among all the bids placed in a given treatment in each period. We consider averages of 6000 simulations for each period. When comparing the actual results from Table 3 to the simulation results, there are two main conclusions. First, simulation on the part 4 individual treatment data, show a reduction of about half of the frequency of winner's curse bids, from 18.3% to 9.4%. This reduction is similar to the actual result for the part 4 group treatment (9.7%, Table 3). Hence, a median aggregation rule in group decision would explain the better performance of groups compared to individuals with respect to placing winner's curse bids. Even if groups do not match the performance of the "truth wins norm", they are still a valuable tool in handling the company takeover task. The role of the group is to reduce the frequency of very high or very low bids entering into the market. While encouraging, this result may not extend to all possible intellective tasks. In particular, it may work in this setting where less than one third of the bids in any given treatment are winner's curse bids but may possibly fail with a more difficult company takeover task where a majority of bids are winner's curse bids.

The second conclusion is that group decision processes cannot be simply reduced to a median-taking rule. This conclusion is based on the simulated and actual fraction of optimal bids. The actual fraction of optimal bids in the group treatment of 50.5% (Table 3) is slightly better than the simulated median bid in the individual treatment (44.4%). This comparison suggests that additional learning took place within groups, which did not take place for stand-alone individuals. At the same time, based on the simulated median bids on the group proposals one may have expected an even better group performance (60.1% vs. 50.5%). A similar conclusion derives from the fraction of winner's curse bids (3.5% vs. 9.75%). While the median proposal has a strong drawing power in group decision making, there are other forces at work, which make decisions worse than the median proposal.

6 Results: Content Analysis of Chat Messages

Additional evidence on group dynamics comes from the analysis of messages exchanged within each group through a chat function. Units of messages were coded for select groups and periods of the experiment in which there was a disagreement in the proposal stage, with at least one of the proposals being a winner's curse bid (282 observations) or when a group's final decision was a winner's curse bid even though none of the other proposal's were winner's curse bids (3 observations).[16] A total of 1150 units of messages fit this criterion. We randomly selected one tenth of the messages to develop a coding scheme, which classifies messages into 22 categories (see Table 6). Two coders trained separately, independently coded the messages according to the coding scheme.[17] The reliabilities of the coding for each category are reported in Table 6.[18]

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[16] Following the methodology utilized in Zhang (2009), a chat unit is defined as a message that was sent out by a subject in a given period during one intervention. Units could be a single word or several sentences entered by the subject before he or she hit the "enter" button to submit the message.
[17] Using binary coding, a message was coded as a 1 if it was deemed by a coder to represent one or more of the 22 categories and 0 otherwise. Each message could be coded under as many or as few categories as the coders deemed appropriate. Messages were coded under one category the majority of time (93.4%), under two categories 6.1% of the time, and rarely coded under three categories (0.5%). Coding instructions are attached in the appendix.
[18] The Kappa statistic measures the degree of agreement between the variables above that expected by chance alone. It has a maximum of 1 when agreement is perfect, 0 when agreement is no better than chance, and negative values

Table 6 provides a summary of the coded messages during the twenty periods of the takeover game.[19] Group discussions were primarily focused on the task, as about 70% of the messages were coded as task focused. Of these messages, participants talked mostly about numerical proposal's (25.4%) or simply expressed agreement to any particular proposal (25.8%). Groups also spent a decent amount of time discussing how to find the best bidding strategy (12.0%+2.1%+3.4%) and how to aggregate conflicting proposals (6.4%+1.6%+0.7%).[20] Statements of threat of disagreement by individual group members were modestly common (6.0%), while an explicit mention of veto power was less common (0.3%+0.1%).[21] There was little mention of losses (3.4%), as the frequency of a loss during the 20 periods of group interactions during the takeover game was low (1.9%).[22]

To see the effects of the various categories of messages, we report regression results in Table 5 (specifications b and c). The probit regressions with robust standard errors (clusters on groups) include all the observations when there is a disagreement in the proposal stage with at least one proposal being a winner's curse bid (282 observations) and when the final group decision was a winner's curse bid even though none of the proposals are winner curse bids (3 observations). Besides the common independent variables included in all regressions,

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when agreement is worse than chance. In general, a Kappa less than 0.20 represents poor agreement, 0.40 represents fair agreement, 0.60 represents moderate agreement, 0.80 presents good agreement and 1.00 represents very good agreement. The p-value is the probability of rejecting the null hypothesis, that agreement between the variables is no better than chance, when it is in fact true. A significant p-value implies that the agreement between the variables is not just chance.

[19] All discussions of coding hereafter are based on the average of the two independent codings, unless otherwise stated. Specifically, the value of the coding is treated as 1 if two coders agreed that a message belongs to a given category; 0 if the two coders agreed that a message does not belong to a given category; 0.5 if two coders disagreed with each other.

[20] A typical quote is "I still like the 60. It's very safe, maximize our potential winnings with little risk."

[21] A typical quote is "I'm going to bit [bid] 60 regardless of your consensus b/c it's the best choice, we win ["avoid winner's curse] if we are in disagreement".

[22] The chat pattern over time suggest that groups spent more time during the first six periods, and the next six periods to a lesser extent, trying to figure out how to succeed at the takeover game. In contrast, the frequency of occurrence for direct pressure and reinforcement was the highest during the first six periods and the last eight periods and dropped slightly during periods seven through twelve.

specification (b) examines whether the median proposal or the proposal that yields the highest expected profit is more likely to prevail as the final group choice. Specification (c) examines whether the winners' cursed proposal or the optimal proposal is more likely to become the final group outcome. Regressors about a proposal being majoritarian or median could not be jointly estimated in Table 5 with proposal being winner's curse or optimal because of multicollinearity issues.

There are a number of notable findings regarding specification (b). First, in periods 7-20, the proposal that was more likely to become the group bid choice proposal was the median bid, especially if in addition it was the majority of the individual group member bid. In periods 1-6, as long as the proposal bid was shared by a majority, it was more likely to prevail. In contrast, the best proposal among the three individual group member proposals did not have a better chance of prevailing. This again provides evidence that truth wins norm does not apply in this environment. In addition, the self-reported confidence interval of a proposal did not seem to matter. The proposals of both economic and business majors and engineering majors were less likely to prevail. The proposals of subjects who had SAT/ACT scores in the low 25% were less likely to prevail in periods 1-6 and more likely to prevail in periods 7-20. Finally, the proposals of males initially (i.e., within the first 6 periods) and of more risk averse participants later on (i.e., within the last 14 periods) were more likely to prevail.

In terms of the chat coding, they are more likely to affect the group outcome in the latter periods. An individual proposal from the member who talked last in the group was less likely to prevail. An individual group member's proposal was more likely to prevail when a group member provided concrete numerical bids as proposal suggestions, when a group member used reinforcement as a means to justify their proposal and when a group member pushed for consensus. An individual group member's proposal was less likely to prevail when he or she discussed irrelevant issues that were unrelated to the takeover game. When people rotated to determine the final group choice, it also reduced the likelihood of a proposal to prevail. Also, when a group member explicitly agreed with a proposal suggested by another group member, his or her proposal was less likely to prevail. A puzzling negative effect on the likelihood of a proposal being prevailed is observed when the group member discussed the best strategies for determining the group's final bid choice.

In specification (c), proposals that are winner's cursed bids and proposals from risk averse subjects in early periods have a negative effect on the likelihood of the prevalence of a proposal. The effects of gender and ability disappear and the effects of majors and the chat coding are similar to what we observed in specification (b).

7 Discussion and Conclusions

The winner's curse is a widespread behavioral bias in common value auctions and in other environments, where people systematically incur in losses when trying to acquire a good. In a company takeover game experiment, individual buyers making take-it-or-leave it offers to company owners frequently fall prey to the winner's curse. Our aim is not to find the origin of the winner's curse but to study whether deciding in groups reduces its magnitude and how this result is achieved.

We report that small groups made better choices than individuals in isolation and substantially reduced the frequency of winner's curse offers (Result 3). Groups make better decisions due to a combination of learning and the way member's proposals are aggregated into a group choice. There are four main results. First, *groups learn faster than individuals*. In our experiment, as well as in most of the literature, there is no significant learning by individuals who bid in a company takeover game (Result 1). We report substantial learning by groups in terms of frequency of optimal bids, dispersed bids, and winner's curse bids (Result 2). This study makes clear that group learning does not come from the simple exposure to diversity of opinions but from engaging in communication and negotiation in search of a consensus. In fact, individual bidding is not significantly different if a subject can observe and imitate the bids of two other subjects without the possibility to chat with them or the need to reach consensus on a bid (Result 5). One contribution of this study has been to clarify what generates group learning.

Second, individual opinions are aggregated within the group largely by taking the *median opinion*. This result is novel. When in disagreement, 75% of groups' choices coincide with the opinion of the median member (Result 6). This percentage is even higher when the median is also the majority opinion (two against one, 80%). Other factors matter, such as risk attitude, some demographic characteristics, and the content of the messages exchanged. The counterintuitive result is that, controlling for all the above factors, the best proposal is *less* likely to emerge than other proposals. The internal dynamics in aggregating individual opinions into a single group choice provides no support for the truth-wins norm. Other papers compare group choices with simulations on individual choices (Cooper and Kagel, 2005, 2009). Instead, this study provides direct evidence by comparing each group choice with the individual proposals of all group members. If two people do not get the correct solution, bringing a smart guy into the group will not be enough, on average, to overturn the group decisions.

Third, there was some *herd behavior*. We provide indirect support on this point. When there was an initial disagreement, the median was more likely to prevail in two-against-one situations than with three distinct opinions (80% vs. 72.6%). While there was a group dynamic to converge to a middle ground as a compromise, this evidence suggests that there also existed another dynamic of herd behavior at play. Such behavior may take the explicit form of pressure from the majority or could be implicit, a self-retreat to conform to the majority. Some chat messages refer to statements or threats to disagree, but not many (6.4%, Table 7). A way to detect the role of minority opinion is to look at the use of veto power. The veto power could have been usefully employed by a subject every time others in the group wanted to place a winner's curse bid. For risk neutral and risk averse participants, a sure gain of zero is preferred to an expected loss. Subjects exerted veto power less often than optimal (Table 5). An optimal use of veto power in groups would have further reduced the frequency of winner's curse bids from 9.7% to 1.5%.

Fourth, we can rule out that the superiority of groups over individuals in the company takeover game is due to shifts in risk attitudes generated by group processes. Very few experiments on group decision making controlled for this possible confounding factor. [23]

Based on the above results we can draw three general lessons about group decision making on intellective tasks. First, g*roup size is a key variable*. Some group experiments are done with two members (Cooper and Kagel, 2005, 2009, Cason and Mui, 1997). If the group choice is generally the median opinion and there is herd behavior, we expect groups of two to behave very differently than groups of three. In other words, when stating a result about groups vs. individuals, one should always specify group size.

Second, groups produce a "*majority boost*." Groups outperform individuals in tasks where a (large) majority of individuals would choose the correct option when deciding in isolation. In those situations, which include our experiment, groups are likely to have a majority

[23] An exception is Sheremeta and Zhang (2010). Following a similar group risk preference elicitation methods, they find groups are more risk averse than individuals yet risk-aversion does not have a significant effect on groups' bidding behavior in contests.

in favor of the correct option. An implication of this study is that in tasks where only a minority of individuals would choose the correct option, groups are expected to *underperform* individuals. This implication is also confirmed by evidence from a pilot experiment with a more difficult version of the company take over game, where companies had 100 different values.[24] Moreover, the poor performance of groups in the common value auctions of Cox and Hayne (2006) and in Sutter et al. (2009) could result from the majority boost. The majority boost also helps to answer a key question for management: *when should we adopt groups in problem solving?* The answer depends on how difficult the task is. We should adopt groups only if the majority of the people are already able to get the right answer when deciding in isolation, otherwise groups are unlikely to improve performance.

Third, *the big advantage of groups is in learning over time*. In a one-shot interaction groups of three are unlikely to beat the truth-wins benchmark when they follow a median aggregation rule. When the majority is correct, they will match the truth-wins benchmark; otherwise, they will likely underperform. They will rarely outperform the truth wins benchmark. In repeated interactions, groups of three may beat a truth-wins benchmark on tasks where group learning is relatively faster than individual learning. A median aggregation rule hinders groups from reaching a truth-wins benchmark but group learning may more than compensate for it. The key to promoting group learning is to craft a communication and negotiation set-up that will engage a positive interaction among members. This includes the default rule in case of disagreement - random, majority, unanimity - and the format of communication - face-to-face, chat, or simple numerical suggestions. In conclusions, are groups better decision-makers than individuals? This question is not well posed as there is no universally valid answer. We cannot

[24] In the pilot session, optimal bids wereonly 3.3% in the individual treatment and 0% in the group treatment. When considering all bids in an interval ranging between optimal-10 and optimal+10, they were 13.3% in the individual treatment and 4.0% in the group treatment.

even conclude that in general groups can overcome the winner's curse. They did in our experiment, but they are likely to fail if we make the task more difficult. This study suggests that the answer will be specific to the task and to the group interaction rules.

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DO GROUPS FALL PREY TO THE WINNER'S CURSE?

Tables and Figures

Table 1: Buyer's profits for selected bids

	Actual profits depending on the company value *s*					Expected
Bid, *b*	*s* = 38	*s* = 60	*s* = 90	*s* = 130	*s* = 240	profits
38 (loss free)	19	0	0	0	0	*3.8*
60 (optimal)	-3	30	0	0	0	*5.4*
90(naïve)	-33	0	45	0	0	*2.4*
130	-73	-40	5	65	0	*-8.6*
240	-183	-150	-105	-45	120	*-72.6*

Table 2: Descriptive statistics for the company takeover bids

	Treatment						
	Individual		Group			Signal	
	part 3 (a)	part 4 (b)	part 3 (c)	part 4 bids (d)	part 4 proposals (e)	part 3 (f)	part 4 (g)
Bid distribution (percentages)							
38 (loss free) and 39	3.3	10	8.6	8.0	9.0	4.4	7.3
60 (optimal) and 61	35.6	37.5	30.6	50.5	48.5	17.8	29.7
90 (naïve) and 91	38.9	31.7	36.7	31.5	30.2	45	40.8
130 and 131	11.1	14	11.7	7.2	6.8	21.1	16.5
240 and 241	1.7	2	1.4	2.5	3.1	1.1	1
All others (dispersed bids)	9.4	4.8	11.1	0.2	2.5	10.6	4.7
Other measures of performance							
Winner's curse (percentage of bids with negative expected profits)	20	18.3	18.3	9.75	10.5	31.1	18.3
Actual profits per period (tokens)	-1.65	0.4	1.21	2.13	2.13	1.41	2.1
Simulated profits per period with optimal bids (tokens)	4.8	6.93	5.73	5.93	5.93	4.8	6.93
Fraction of obs. with low cash balances (limited liability)	0%	2%	0.8%	3.2%	--	0%	0%
Number of obs., Number of subjects	180, 30	600, 30	360, 60	400,60	1200,60	180, 30	600, 30

Notes to Table 2: Distribution of bid signals for (g) is the same as for (b)

Table 3: Who placed optimal bids and winners' curse bids

	All treatments (part 3 – Individual bids)		Individual treatment (part 4)		Group treatment Individual proposals (part 4)		Signal treatment (part 4)	
Dependent variable	Optimal bid (a)	Winner's curse bid (b)	Optimal bid (c)	Winner's curse bid (d)	Optimal proposal (e)	Winner's curse proposal (f)	Optimal bid (g)	Winner's curse bid (h)
Risk averse (switch point>13)	0.07	-0.04	(^)	(^)	-0.06	-0.06*	(~)	(~)
	(0.09)	(0.07)			(0.14)	(0.03)		
Risk seeking (switch point<8)	-0.13	-0.08	(^)	(^)	(~)	(~)	-0.15	0.30
	(0.08)	(0.08)					(0.11)	(0.26)
High confidence in bid or proposal	(-)	(-)	0.05	-0.09	0.02	-0.08***	-0.13**	0.24*
			(0.14)	(0.08)	(0.08)	(0.03)	(0.06)	(0.13)
Demographics								
Economics and Business Major	0.10	-0.06	0.31***	-0.08	0.14	0.06	-0.24	0.10
	(0.09)	(0.08)	(0.09)	(0.06)	(0.13)	(0.09)	(0.16)	(0.15)
Science and Engineering Major	0.20***	-0.11	0.40***	-0.10	0.13	0.02	-0.44***	0.16
	(0.08)	(0.09)	(0.11)	(0.08)	(0.14)	(0.07)	(0.11)	(0.19)
Bottom 25percentile SAT/ACT	-0.10*	0.24***	0.05	0.00	-0.01	0.01	-0.13*	-0.09*
	(0.06)	(0.08)	(0.14)	(0.08)	(0.12)	(0.04)	(0.08)	(0.05)
Male	0.05	0.07	0.00	0.14***	0.02	0.05	-0.11	0.04
	(0.06)	(0.06)	(0.14)	(0.04)	(0.09)	(0.03)	(0.08)	(0.09)
Missing demographic data	-0.02	0.06	-0.25***	0.22**	-0.14	0.09	-0.18*	0.06
	(0.10)	(0.13)	(0.07)	(0.11)	(0.16)	(0.14)	(0.10)	(0.11)
1/period	-0.07	-0.08	1.20	-0.12	-1.69**	-0.06	-1.49*	0.98
	(0.07)	(0.06)	(0.92)	(0.65)	(0.71)	(0.29)	(0.89)	(0.63)
At least one signal from two other subjects is optimal bid							0.08	
							(0.06)	
Both signals from two other subjects are optimal bids							0.04	
							(0.10)	
At least one signal from two other subjects is winner's curse bid								0.01
								(0.04)
Both signals from two other subjects are winner's curse bids								-0.09**
								(0.04)
Number of observations, Number of subjects	717, 120	717, 120	589, 30	589, 30	1166, 60	1166, 60	600, 30	600, 30
Pseudo R-squared	0.098	0.098	0.090	0.071	0.058	0.086	0.233	0.249
Log likelihood	-387.8	-355.3	-354.1	-259.3	-760.5	-353.3	-279.9	-215.9

Notes to Table 3: Marginal effects from probit regression with robust errors on individuals. Observations with low cash balance were excluded from the regression (limited liability issue). Four dummies for the value taken by the company in the previous period were in the regression but not reported in the table, value_was60, value_was90, value_was130, value_was240 (company value was 60, 90, 130 or 240 in the last period); for period one they were set to zero value. (-) Across all treatments subjects were required to indicate the level of confidence on the bid in part 4 but not in part 3. (^) everyone in this treatment is risk neutral or moderately risk averse. (~) risk preference regressors are dropped because of collinearity Session dummies were included in the regression but not reported in the table. Robust standard errors are in parentheses. Significance levels are *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 4: Aggregation of individual proposals into a group choice

Group treatment, Part 4

Group classification based on individual proposals:	No. of proposals	Actual no. of winner's cursed bids	Expected no. of winner's cursed bids if subjects exercise veto power
No winner's curse proposals	912	3	0
There is only one winner's curse proposal	216	54	0
There are two winner's curse proposals	54	42	0
All winner's curse proposals	18	18	18
Total	1,200	117	18
Frequency of winner's curse (out of 1200)	10.6%	9.7%	1.5%

Table 5: Solving disagreement among individual proposals

Group treatment, Part 4

Dependent variable: 1=individual proposal became group choice, 0= otherwise	All obs. Periods 1-6 (a)	All obs. Periods 7-20 (a)	Periods 1-6 (b)	Periods 7-20 (b)	Periods 1-6 (c)	Periods 7-20 (c)
Proposal is median and majority	0.67***	0.69***	0.95***	0.73***		
	(0.06)	(0.04)	(0.02)	(0.13)		
Proposal is median but not majority	0.05	0.40***	0.15	0.39**		
	(0.15)	(0.05)	(0.16)	(0.16)		
Among group proposals, it yields	0.14	-0.11*	-0.24*	-0.34*		
the highest expected profit	(0.09)	(0.06)	(0.13)	(0.19)		
Proposal is winner's curse					-0.45***	-0.01
					(0.13)	(0.15)
Proposal is optimal: 60 or 61					-0.19	-0.10
					(0.13)	(0.13)
Low cash endowment,	0.14	0.05	(^)	-0.19	(^)	-0.11
below limited liability threshold	(0.31)	(0.24)		(0.14)		(0.15)
Subject is risk averse	0.03	0.09	-0.20	0.35**	-0.42***	0.05
(switch point>13)	(0.13)	(0.10)	(0.21)	(0.15)	(0.13)	(0.20)
Subject is risk seeking	-0.31***	-0.06	-0.00	-0.17	0.12	-0.06
(switch point<8)	(0.12)	(0.09)	(0.22)	(0.19)	(0.17)	(0.18)
High confidence proposal	-0.13	0.06	-0.36	0.02	-0.00	0.07
	(0.10)	(0.07)	(0.24)	(0.13)	(0.21)	(0.14)
Demographics						
Economics and Business major	0.01	0.03	-0.17	-0.46***	-0.53***	-0.54***
	(0.15)	(0.11)	(0.31)	(0.12)	(0.17)	(0.08)
Science and Engineering major	0.05	0.09	-0.37**	-0.33**	-0.52***	-0.37***
	(0.14)	(0.10)	(0.18)	(0.15)	(0.17)	(0.10)
Bottom 25% SAT/ACT score	-0.19*	0.07	-0.40*	0.20**	-0.06	0.11
	(0.10)	(0.08)	(0.21)	(0.09)	(0.23)	(0.12)

Male	0.14	-0.01	0.48***	-0.13	0.07	-0.16
	(0.09)	(0.07)	(0.12)	(0.12)	(0.13)	(0.15)
Missing demographic data	0.02	0.13	0.22*	0.13	0.07	-0.16
	(0.15)	(0.10)	(0.13)	(0.19)	(0.23)	(0.23)
Chat message coding						
I talked first (1 or 0)			-0.07	0.22	0.11	0.08
			(0.27)	(0.19)	(0.19)	(0.16)
I talked last (1 or 0)			0.03	-0.23**	-0.03	-0.16**
			(0.21)	(0.11)	(0.11)	(0.08)
Numerical			-0.00	0.13***	-0.00	0.10***
			(0.07)	(0.04)	(0.05)	(0.03)
Think			-0.07	-0.24**	-0.04	-0.25***
			(0.09)	(0.10)	(0.06)	(0.08)
Pressure			0.01	0.08*	-0.05	0.08
			(0.19)	(0.04)	(0.09)	(0.05)
Reinforcement			-0.11	0.47***	0.10	0.50***
			(0.16)	(0.13)	(0.13)	(0.13)
Loss			-0.18	0.11	0.12	0.13
			(0.17)	(0.12)	(0.09)	(0.08)
Aggregate			0.15	(-)	-0.16*	(-)
			(0.11)		(0.09)	
Rotate			0.49	-0.66***	0.23	-0.50**
			(0.41)	(0.22)	(0.34)	(0.24)
Agreement			-0.22**	-0.01	-0.25***	-0.02
			(0.10)	(0.06)	(0.09)	(0.06)
Irrelevant			-0.07*	-0.05*	-0.04	-0.02
			(0.04)	(0.03)	(0.04)	(0.03)
Number of obs., Number of subjects	240, 60	405, 60	101, 39	176, 36	101, 39	176, 36
Pseudo R-squared	0.370	0.325	0.564	0.405	0.246	0.187
Log likelihood	-104.1	-188.6	-30.48	-72.53	-52.79	-99.18

Notes to Table 5: Probit regression with robust standard errors (clusters on groups). Significance levels *** p<0.01, ** p<0.05, * p<0.1. Specifications (a) include all individual proposals unless all identical within the group in a given period (645 obs.) Specifications (b) and (c) include all the observations when there is a disagreement in the proposal stage with at least one proposal is a winners' cursed bid (282 obs.) and when the final group decision is winner's cursed bid even though none of the proposals are winner's cursed bids (3 obs.). (^) for periods 1-6, the limited liability regressor is a structural zero: it perfectly predicts failure (proposal does not prevail in group choice), one observation is dropped from the regression; (-) for period 7-20, chat message coding "aggregate" regressor perfectly predicts failure, 7 observation are dropped from the regression.

Table 6: Messages in groups facing winner's curse proposals

Code	*Category Description*	*Kappa*	*Z*	*Frequency % coder1*	*Frequency % coder2*	*Average frequency*
	a - talk about numerical bids					**25.44**
19	Persuade other to bid 60	0.9275	31.45	3.74	3.74	
20	Persuade others to bid 90	0.8903	30.19	9.57	9.74	
21	Persuade others to place a very high bid (i.e., any bid above 94)	0.9528	32.31	10.09	10.43	
16	Argue in favor of their own bid	0.9255	31.39	1.74	1.83	
	b - thinking process of individual except mentioning losses					**11.96**
5	Talk about past random draws	0.6978	23.66	1.39	1.83	
6	Learning through trials and errors	0.9087	30.81	0.43	0.52	
8	Think through the potential payoffs of a given bid for alternative random draws	0.8885	30.13	0.43	0.35	
9	Stick to the same bid for several periods	0.9728	32.99	3.22	3.39	
2	Take risks, enjoyment of risky choices	0.9059	30.72	3.13	3.57	
3	Play safe, fear of risky choices	0.8892	30.15	2.7	2.96	
	c - direct pressure (statements or threats to disagree)					**6.39**
10	Threat to disagree with others in the final group decision	0.6662	22.59	0.09	0.17	
11	Talk about earning zero in case of disagreement	1	33.91	0.26	0.26	
18	Disagreement with someone else's proposals	0.9537	32.34	5.91	6.09	

	d - reinforcement					**2.13**
12	Explicitly refer to the success or failure of past bids in making the current group choices	0.854	28.96	1.83	2.43	
	e - talk of losses					**3.4**
7	Mention losses or avoiding losses	0.8077	27.39	1.48	1.74	
4	Talk about current losses being large or not being able to make them up. The experimenter cannot force the payment of losses at the end of the session.	0.8758	29.7	1.57	2	
	f - aggregating bids by median or majority					**1.61**
13	Pick the bid proposed by the majority	0.9519	32.28	0.87	0.96	
14	Pick the bid in the middle (median rule)	0.8741	29.64	0.61	0.78	
	g - rotating scheme					**0.65**
15	Talking about taking turns among participants in determining group choice	0.7987	27.08	0.52	0.78	
	h - agreement					**25.79**
17	Agreement with someone else's proposals	0.9296	31.52	25.57	26	
	i - other irrelevant words					**31.18**
1	I am not sure or I am confused about what to bid	0.8601	29.17	3.74	4.7	
22	Other	0.8675	29.42	28.26	25.65	

Notes: no. obs.: 1150 units in total. Prob>K is 0.000 for all lines.

Figure 1: Fraction of optimal bids over time

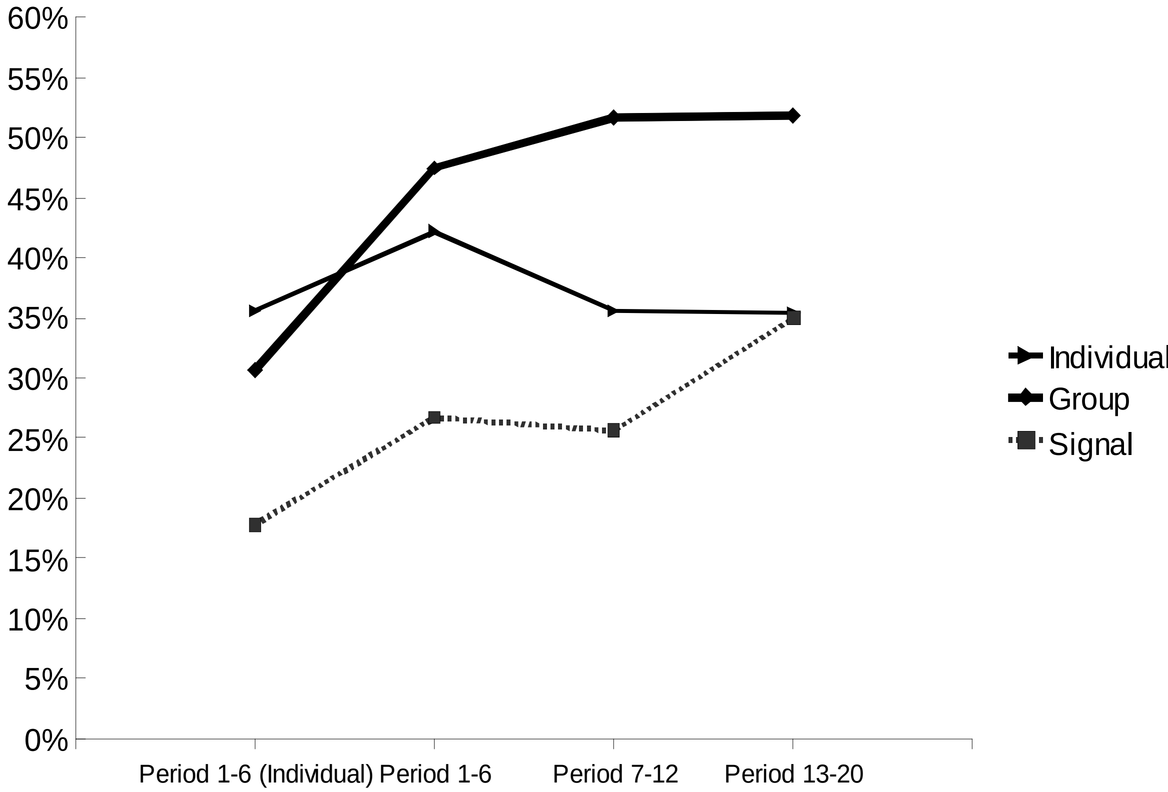

Figure 2: Fraction of winner's curse bids over time

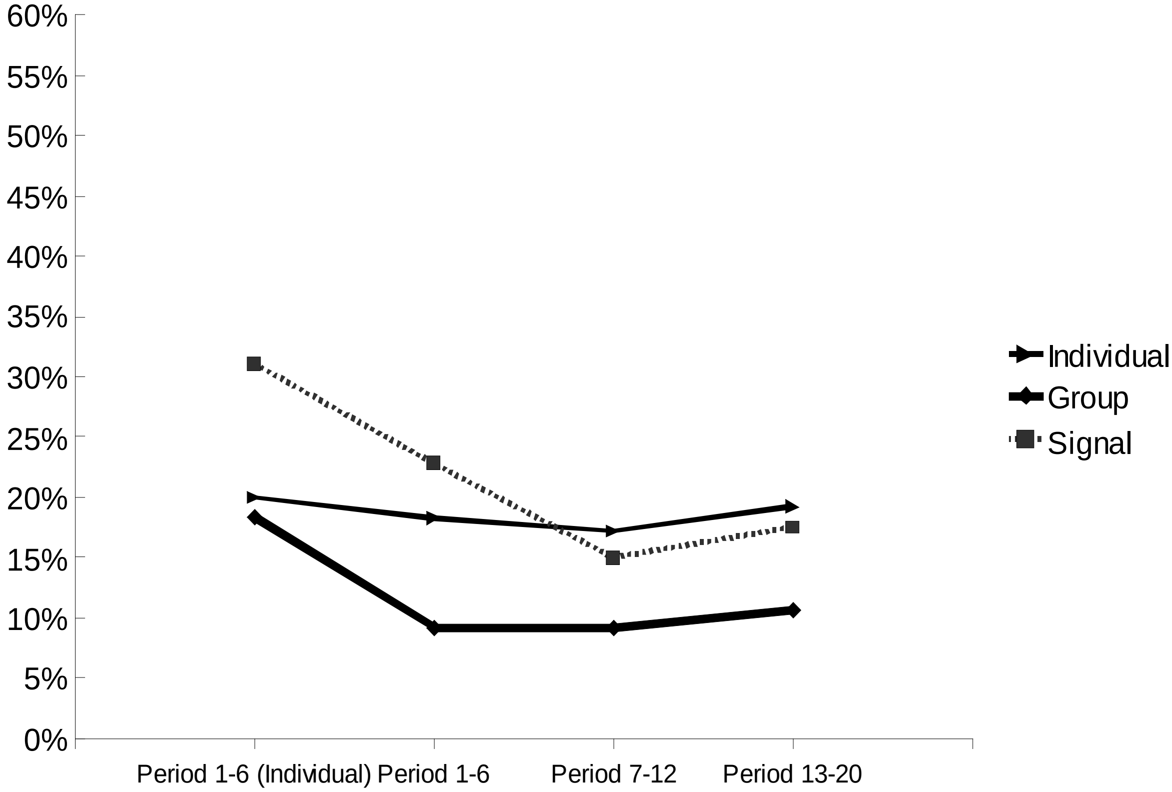

Figure 3: Fraction of dispersed bids over time

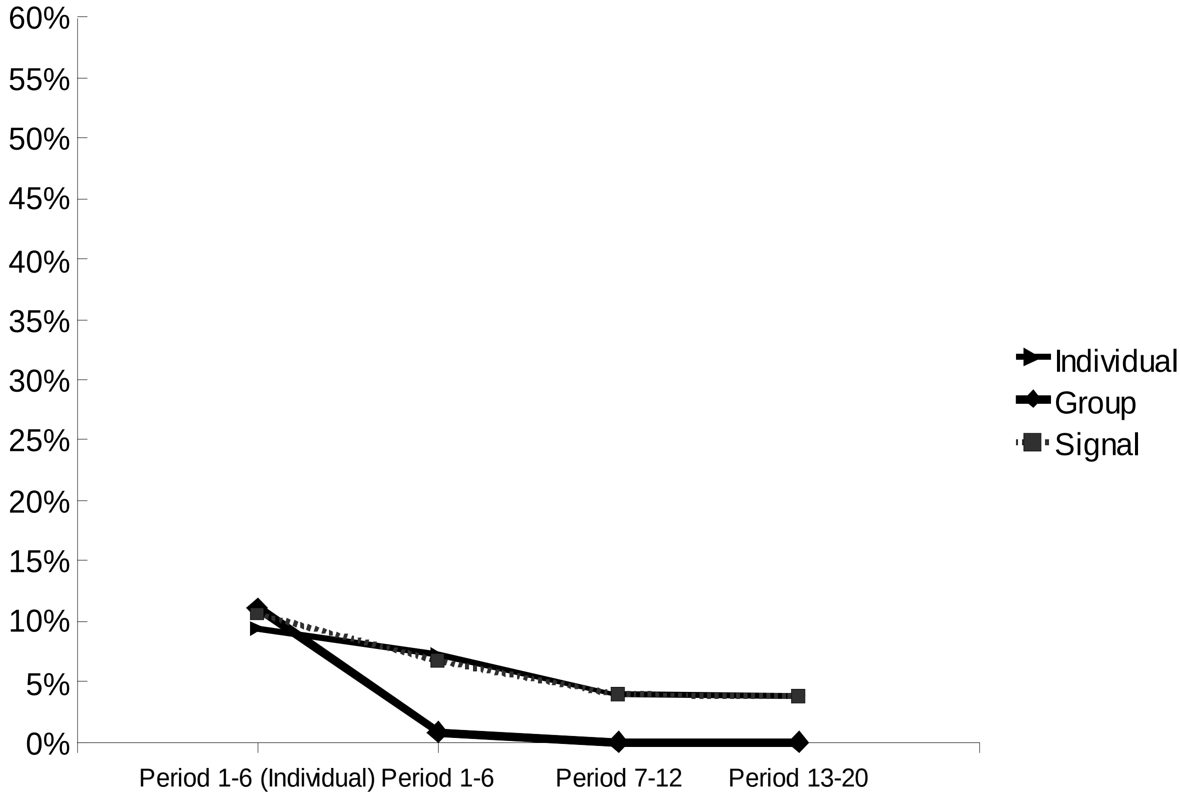

Figure 4: Lottery choices in group (part 2)